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Trematodes of the Genus *Allocreadium* (Allocreadiidae) from Freshwater Fishes of Japan

By

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Abstract This paper deals with the following species of the trematode genus *Allocreadium* LOOSS, 1900 (Allocreadiidae), found in freshwater fishes of Japan: *A. gotoi* (HASEGAWA et OZAKI, 1926), comb. n. (syn. *Macrolecithus gotoi* HASEGAWA et OZAKI, 1926); *A. hasu* OZAKI, 1926; *A. isoporum* (LOOSS, 1894) LOOSS, 1900; *A. japonicum* OZAKI, 1926; *A. tosai* sp. n.; and *Allocreadium* sp. of KATAOKA and MOMMA (1934). The morphology of each species is described and illustrated, and its systematic position is discussed. *Allocreadium tosai* from *Tribolodon hakonensis*, *T. ezoe* and *Moroco percnurus sachalinensis* of Hokkaido differs from the most closely allied species, *A. baueri* SPASSKII et ROITMAN, 1960, in a larger body, a smaller sucker width ratio and larger eggs. *Macrolecithus* HASEGAWA et OZAKI, 1926, is regarded as a synonym of *Allocreadium*, and four species (including the type species) previously placed in *Macrolecithus* are transferred to *Allocreadium* as a new combination. In addition, some unidentified related trematodes are recorded.

The study of trematodes parasitizing freshwater fishes of Japan has a history of no less than 80 years. It began in 1905 when metacercariae of an unidentified trematode were reported from Japanese freshwater fishes (FUJITA, 1905). As to the morphology and taxonomy of adult trematodes, *Leptolecithum eurytremum* and *Exorchis oviformis*, new genera and species, were the first described from them (KOBAYASHI, 1915). Since then, 28 other new and 8 known species, apart from some unidentified adults and many species of metacercariae, in 19 genera have been reported. A few of the species have been restudied in detail with some taxonomic changes after original descriptions. The rest remain for further evaluation. Some have appeared only once in the literature, and, what is worse, it is believed that their original type series or specimens have been discarded or destroyed after the retirement or death of their authors.

From fresh waters of Japan have been recorded 3 species in 1 family of jawless fishes (order Petromyzonida) and more than 160 species in about 30 families of bony fishes (superorder Teleostei), both native and introduced. Many of the latter alone are known to serve as final or definitive hosts for the trematodes in Japan. Examinations of freshwater fishes for adult trematodes have relatively often been made in some limited geographical areas (rivers and lakes) of the Hokkaido, Kantô, Chûbu

and Kinki districts, but very few, if any, have been attempted in others. Moreover, it seems that even in the areas investigated, not all of the fish species inhabiting there have been examined.

In a series of papers, of which this is the first, I will gather the existing knowledge of the adult trematodes once found in the Japanese freshwater fishes. This paper deals with trematodes of the genus *Allocreadium* LOOSS, 1900, in the family Allocreadiidae STOSSICH, 1903. The morphology of each species is first described, and then the systematic position is discussed. A few species, possibly marine or brackish water, detected in anadromous or brackish-water fishes, and metacercariae are excluded. Valuable information about the host, life cycle and geographical distribution of each species will be added. KOBAYASHI (1935) wrote the book concerning the Japanese freshwater fishes and their parasites including the trematodes known at that time. YAMAGUTI (1975) published an extensive review of the literature on the trematode life cycles. For the metacercariae reported from the Japanese freshwater fishes, refer to KOMIYA (1965).

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Materials and Methods

Most descriptions and figures given for trematodes from Japanese freshwater fishes were used. Published or unpublished museum specimens were studied as many as possible when available. They were whole-mounted or serially-sectioned ones prepared by varying methods and borrowed from the collections of Dr. Satyu YAMAGUTI and Dr. YOSHIMASA OZAKI deposited at the Meguro Parasitological Museum (MPM), Tokyo; the collection of Dr. Tsunenobu FUJITA deposited at the Department of Applied Zoology, Faculty of Agriculture, Hokkaido University, Sapporo; the collection of Dr. Naoki SEKI (1975) deposited at the Department of Parasitology,

Faculty of Veterinary Medicine, Hokkaido University, Sapporo; and my collection (SHIMAZU, 1981) deposited at the National Science Museum, Tokyo (NSMT). Some identified specimens borrowed from the collection of the Institute of Parasitology, Czechoslovak Academy of Sciences, Prague, were used for comparison.

New specimens were collected by Dr. Kazuya NAGASAWA and by myself. They were flattened under slight pressure, fixed in SCHAUDINN's or NOZAWA's fluid or 70% ethanol, stained with HEIDENHAIN's iron hematoxylin or alum carmine, and mounted in Canada balsam. They are deposited at the NSMT.

All measurements (length by width) are in millimeters, unless otherwise noted. The fish nomenclature used is based mainly on the ICHTHYOLOGICAL SOCIETY OF JAPAN (1981). When host fish names, particularly of unpublished parasites, were indicated only by Japanese local or vernacular names on the labels, it was often impossible to put them into scientific names. In such cases, they will be cited as they are, followed by presumptive scientific names given together with the question mark in parentheses. Besides, it was too difficult to read correctly locality names written only in Chinese characters on labels. These locality names will be presented in their possible readings in brackets.

Family Allocreadiidae STOSSICH, 1903

Family diagnosis. Trematoda, Allocreadioidea. Body elongate, aspinose, oculate or not. Oral sucker subterminal, with or without muscular papillae. Prepharynx very short or practically absent. Pharynx present. Esophagus variable in length; intestinal ceca long, terminating blindly near posterior end of body. Ventral sucker in anterior half of body. Testes usually two, very rarely four, in tandem or diagonal in hindbody. Cirrus pouch present, in front of or overlapping ventral sucker, enclosing seminal vesicle, prostatic complex and cirrus; no external seminal vesicle. Genital atrium poorly developed. Genital pore median, between pharynx and ventral sucker. Ovary median, submedian or almost lateral, pretesticular. Ootype-complex, LAURER's canal and seminal receptacle usually postovarian, rarely on median side of ovary. Uterus winding, usually pretesticular, occasionally extending into inter- or post-testicular space; metraterm present. Eggs operculate, usually not embryonated, rarely fully embryonated. Vitellaria follicular, distributed along ceca, limited in extent or not. Excretory vesicle tubular, epithelial, varying in length, with postero-terminal or almost dorsal pore. Adults parasitic almost exclusively in intestine of freshwater fishes and amphibians.

Miracidia with one eyespot (two finally fused into one); flame cells two; epidermal cell formula reportedly 6, 6, 4, 2, or 6, 7, 4, 2. Ophthalmoxiphidiocercariae produced in rediae in lamellibranch mollusks (Sphaeriidae) or prosobranch snails or, rarely, aquatic pulmonate snails (limpets); flame cell formula probably $2[(n+n+n)+(n+n+n)]=12n$ ($n=2, 3$ or 4). Metacercariae encysting in aquatic arthropods or mollusks, occasionally progenetic.

Genus *Allocreadium* LOOSS, 1900

Syn.: *Creadium* LOOSS, 1899, preoccupied; *Macrolecithus* HASEGAWA et OZAKI, 1926; *Neoallocreadium* AKHMEROV, 1960.

Generic diagnosis. Allocreadiidae, Allocreadiinae. Body oculate or not. Oral sucker without muscular papillae. Genital pore near intestinal bifurcation. Uterus usually pretesticular, or sometimes extending to inter- or post-testicular region. Eggs not embryonated. Vitelline follicles confined to hindbody or extending into forebody, distributed to posterior end of body, confluent behind posterior testis. Parasitic in intestine of freshwater fishes and amphibians.

Ophthalmoxiphidiocercariae developing in rediae in fingernail clams (sphaeriids or pisidiids), prosobranch snails or limpets (ancylids); flame cell formula reportedly $2[(3+3)+(3+3)]=24$, $2[(3+3+3)+(3+3+3)]=36$, or $2[(4+4+4)+(4+4+4)]=48$. Metacercariae encysting in aquatic arthropods or mollusks, occasionally progenetic.

Type species: *A. isoporum* (LOOSS, 1894) Looss, 1900.

Allocreadium gotoi (HASEGAWA et OZAKI, 1926), comb. n.

(Figs. 1–3)

Syn.: *Macrolecithus gotoi* HASEGAWA et OZAKI, 1926.

Material examined. 1) One serially-sectioned gravid specimen (unidentified, MPM Coll. No. 30009) in Dr. OZAKI's collection from *Misgurnus anguillicaudatus* (Cobitidae) (other data not given). The sections of the anteriormost part of the forebody were lacking.

2) One gravid whole-mount of *M. gotoi* (MPM Coll. No. 22571) in Dr. YAMAGUTI's collection from the intestine of the same species of fish from Kôga, Shiga Prefecture, on July 8, 1927.

3) One serially-sectioned and 6 whole-mounted gravid specimens of *M. gotoi* (MPM Coll. No. 22567) in the same collection from the stomach and intestine of the same species of fish from Shichigô (now in Sendai), Miyagi Prefecture, on August 3, 1927.

4) Two gravid whole-mounts of *M. gotoi* (MPM Coll. No. 22570) in the same collection from the intestine of the same species of fish from [Kômi] (?Nagano Prefecture) on August 29, 1927.

5) One serially-sectioned gravid specimen (unidentified, MPM Coll. No. 22568) in the same collection from the intestine of the same species of fish from Zeze, Shiga Prefecture, on July 16, 1928.

6) Four gravid whole-mounts of *M. gotoi* (MPM Coll. No. 22294) in the same collection from the intestine of the same species of fish from an unknown locality on June 23, 1932.

7) Nine gravid whole-mounts of *M. gotoi* (unpublished, MPM Coll. No. 22575) in the same collection from the stomach of the same species of fish from [Mikawa]

Sh. KAMEGAI on April 19, 1972.

11) One gravid whole-mount of *M. gotoi* (unpublished, MPM Coll. No. 22572) in the same collection from the intestine of "Moroko" (= ?*Gnathopogon elongatus caerulescens*) (Cyprinidae) from Lake Biwa, Shiga Prefecture, on July 9, 1927.

12) One gravid whole-mount of *Allocreadium* (unpublished, MPM Coll. No. 22569) in the same collection from the intestine of the same species of fish from Lake Biwa on July 29, 1927.

13) Nine gravid whole-mounts (NSMT-P1 2929–2930) found in the intestine of *M. anguillicaudatus* from Lake Kizaki, Nagano Prefecture, on August 28, 1981, and July 24, 1983.

14) Three immature and 4 gravid whole-mounts (NSMT-P1 2931–2932) found in the intestine of the same species of fish from the Oono River, near Hakodate, Hokkaido, on August 20 and 23, 1984.

15) One immature whole-mount (NSMT-P1 2933) found in the intestine of *Chaenogobius annularis* (the middle-reaches type) (Gobiidae) from the same locality on August 20, 1984.

Description. 1) Based on material 13 (Figs. 1–3). Body elongate-obovate or cylindrical, 2.30–4.50 by 0.80–1.30; forebody 33–41 % of total body length. Eyespot pigments solid or dispersed on both sides of pharynx. Oral sucker round, 0.32–0.47 by 0.30–0.47, usually with large aperture. Prepharynx very short. Pharynx globular, large, 0.15–0.24 in diameter. Esophagus winding, short, 0.12–0.20 long, bifurcating midway between two suckers; intestinal ceca rather thick, reaching near posterior end of body. Ventral sucker round, larger than oral sucker, located at anterior one-third of body or slightly behind it, 0.42–0.61 by 0.40–0.57; sucker width ratio 1: 1.20–1.31.

Testes elliptical, rather small, almost tandem, usually separated from each other in middle one-third of hindbody, 0.26–0.47 by 0.24–0.40. Cirrus pouch small, elongated, curved or not, very thin-walled, in front of ventral sucker or very slightly overlapping it, 0.16–0.31 by 0.08–0.14. Seminal vesicle tubular, constricted or not, occupying posterior two-thirds of cirrus pouch. Pars prostatica oval, small, accompanying a large number of prostatic cells. Cirrus short, not protrusible. Genital atrium inconspicuous. Genital pore just postbifurcal. Ovary globular or subglobular, median, posterior to ventral sucker, 0.21–0.34 by 0.16–0.27. Ootype-complex postovarian. Seminal receptacle oval to elliptical, between ovary and anterior testis, 0.16–0.31 by 0.12–0.17. LAURER's canal short. Uterus entering posttesticular region in specimens more than 3.60 long; metraterm shorter than cirrus pouch, surrounded with gland cells. Eggs numerous, non-embryonated, 80–94 by 46–54 μm in balsam. Vitelline follicles irregular in shape, rather large, distributed usually between bifurcal level and posterior end of body, rarely extending anteriorly to pharyngeal or ventral sucker level. Excretory vesicle I-shaped, thick-walled, ending about midway of posttesticular region; excretory pore posteroterminal.

2) Material 2–6, probably prepared unflattened (YAMAGUTI, 1934), measured

1.30–3.40 long. The four specimens of material 6 were 1.30–1.92 long and possessed a large cirrus pouch which contained a voluminous S-shaped seminal vesicle and extended backward farther than the midlevel of the ventral sucker, as described by YAMAGUTI (1934), and the uterus entering the posttesticular region. Out of the remaining nine, which were 1.56–3.40 long and with a much smaller cirrus pouch, seven (1.56–2.60 long) had the uterus restricted anterior to the posterior border of the posterior testis, and two (2.70–3.40 long) possessed the uterus extending into the posttesticular region. In material 12, the excretory vesicle reaching the posterior testis. This is probably due to the fact that the posterior part of this specimen was somewhat contracted. All the others examined were morphologically similar to material 13 described above.

Discussion. HASEGAWA and OZAKI (1926) created a new genus, *Macrolecithus*, with this species as the type species from the intestine of *M. anguillicaudatus* without mentioning the type locality. The holotype (No. P. 270) was deposited by them in the collection of the Zoological Institute, Science Faculty, Imperial University of Tokyo, but most presumably it has already been lost. It is quite uncertain whether or not material 1 is the component of the original type series. Later, YAMAGUTI (1934) briefly described his own specimens of the trematode. It seems very likely that he used material 2–6 then, though he did not record the host or locality either.

As regards the validity of *Macrolecithus*, it has been an open question (REES, 1968; LAMBERT, 1974; MORAVEC, 1984). MORAVEC (1984) suggested that this genus might be a synonym of *Allocreadium*. The present study has shown that vestiges of cercarial eyespots are still retained in adults of *M. gotoi*. YAMAGUTI (1971) placed the genus in the subfamily Macroderoidinae ODENING, 1964 (family Macroderoididae McMULLEN, 1937). The aspinose body and the presence of the eyespots in *M. gotoi* eliminate it from the subfamily. So far as the adult morphology is concerned, no significant differences can be seen between *Macrolecithus* and *Allocreadium*. The posttesticular extent of the uterus is said to be one of the most important characters of *Macrolecithus* (HASEGAWA & OZAKI, 1926). According to HASEGAWA and OZAKI (1926), the uterine area enlarges with the growth of worms, and the uterus enters the posttesticular region in large adults more than 2.50 long, whereas it is confined pretesticular in smaller adults less than 1.91 long. This agrees fairly well with the present observation. The uterus is often seen extending into the intertesticular space or even into the posttesticular region in some members of *Allocreadium*, for example, *A. carparum* ODENING, 1959 (ODENING, 1959; MORAVEC, 1984) and *A. (Allocreadioides) multivitellatum* WANG, 1984 (WANG, 1984). Consequently, it seems that the topography of the uterus attains no generic importance. I am of opinion that *Macrolecithus* should be reduced to a synonym of *Allocreadium*, and accordingly *M. gotoi* becomes *A. gotoi* (HASEGAWA et OZAKI, 1926), comb. n. This species somewhat resembles *A. transversale* (RUDOLPHI, 1802) ODHNER, 1901, a parasite of *M. fossilis* and *Cobitis taenia* in Europe, but differs from it (ODHNER, 1901; SZIDAT, 1938; ERGENS, 1964; ŽITŇAN, 1966; KOVAL', 1972) in a much smaller sucker width ratio, the uterus

descending into the posttesticular region and smaller eggs. The species is distinguishable from all other previously known species of the genus by the combination of the following features: the esophagus being short; the ventral sucker being situated at some distance behind the intestinal bifurcation; the genital pore being just postbifurcal; and the uterus extending into the posttesticular space. *M. elongatus* PARK, 1939, *M. phoxinusi* [sic] PARK, 1939 (PARK, 1939), and *M. indicus* GUPTA et AGRAWAL, 1967 (GUPTA & AGRAWAL, 1967) are transferred to *Allocreadium* as a new combination. Both *A. elongatum* and *A. phoxini* were detected in *Phoxinus lagowskii* from the same locality (Sensen, North Korea) on June 26 and 28, 1938. PARK (1939) separated the former from the latter mainly by the eggs being ellipsoidal and thick-shelled instead of ovoidal and thin-shelled. It is quite uncertain whether or not these differences are of specific importance. They need to be restudied and compared with other *Allocreadium* trematodes of *Phoxinus* fishes in the Palaearctic subregion: *A. baueri* SPASSKIĭ et ROĬTMAN, 1960 (SPASSKIĭ & ROĬTMAN, 1960; KOVAL', 1972); *A. papilligerum* (REES, 1968) MORAVEC, 1984 (= *M. papilliger* REES, 1968) (REES, 1968; MORAVEC, 1984); and the form of BELOUS (1952). BESPROZVANNYKH (1984) claimed to obtain *A. baueri* from *P. l. oxycephalus* from Lake Khanka, Primor'e, USSR, and regarded BELOUS' trematode as this species. However, the former (KOVAL', 1966) appears to differ from the latter (KOVAL', 1972) in a shorter esophagus, the position of the ventral sucker, a smaller sucker width ratio, a shorter anterior extent of the vitellaria and smaller eggs. SRIVASTAVA and GHOSH (1967) erected a new genus and species, *Paramacrolecithus rasborai*, in the subfamily Walliniinae YAMAGUTI, 1958 (Allocreadiidae). In this species, the submedian genital pore is postbifurcal and anterolateral to the ventral sucker, and the excretory vesicle extends as far as the ovary. YAMAGUTI (1971) took this genus as a subgenus of *Macrolecithus*. Restudy of the morphology of the trematode, especially of the position of the genital pore, is needed before its possible systematic position is determined.

Allocreadium gotoi is parasitic in the stomach and intestine of *M. anguillicaudatus* and "Moroko" in the Hokkaido, Chûbu and Kinki districts, Japan. Its life cycle is unknown. For that of *A. papilligerum*, see LAMBERT (1974) and MORAVEC (1984). There is a marked discrepancy in the flame cell formula previously reported for this trematode: $2[(3+3)+(3+3)]=24$ (REES, 1968) and $2[(3+3+3+3)+(3+3+3+3)]=48$ (LAMBERT, 1974). These findings need verification.

Allocreadium hasu OZAKI, 1926

(Figs. 4-5)

Material examined. 1) Six serially-sectioned and 11 whole-mounted gravid specimens of *A. hasu* (MPM Coll. No. 30006) in Dr. OZAKI's collection from *Opsariichthys uncirostris* (Cyprinidae) from Lake Biwa, Shiga Prefecture (other data not given).

2) Six gravid whole-mounts of *A. hasu* (MPM Coll. No. 22287) of YAMAGUTI

(1934) from the "stomach and small intestine" of the same species of fish from Omatsu (=Lake Biwa) on July 10 and 17, 1927. (The stomach is lacking in cyprinid fishes. In this series, accordingly, the "stomach" is regarded as the upper part of the intestine, and the "small intestine" as the middle and lower parts.)

3) One gravid whole-mount (NSMT-P1 2934) found in the intestine of the same species of fish from Lake Biwa on June 6, 1980.

Description. 1) Based on material 1; 10 measured (Figs. 4–5). Body elongate-oval, 4.20–5.80 by 1.10–1.80; forebody 16–26% of total body length. Large gland cells with ducts opening at anterior tip of body and fine eyespot pigments present in forebody. Oral sucker rather small, 0.31–0.37 by 0.28–0.47. Prepharynx very short. Pharynx 0.16–0.23 by 0.15–0.23. Esophagus long, 0.47–0.79 long, bifurcating between anterior and posterior border of ventral sucker; intestinal ceca ending in posterior half of posttesticular region. Ventral sucker located at posterior border of anterior one-fourth to one-fifth of body, 0.43–0.59 by 0.47–0.67; sucker width ratio 1: 1.41–1.66.

Testes deeply indented, large, tandem, in third one-fourth of body, 0.55–1.02 by 0.59–1.02. Cirrus pouch claviform, small, not extending posterior to ventral sucker, 0.21–0.79 by 0.15–0.47. Seminal vesicle tubular, convoluted, occupying half or most part of cirrus pouch. Pars prostatica oval, small. Cirrus short. Genital atrium not seen. Genital pore between pharynx and ventral sucker. Ovary 3-lobed or subspherical, median, 0.36–0.47 by 0.31–0.67, between ventral sucker and anterior testis. Seminal receptacle globular, postovarian, 0.15–0.41 by 0.15–0.39. Ootype-complex and LAURER's canal postovarian. Uterine coils between anterior testis and ventral sucker, sometimes overlying slightly on anterior testis; metraterm weakly developed, shorter than cirrus pouch. Eggs numerous, non-embryonated, 64–78 by 46–56 μm in balsam. Vitelline follicles round or elliptical, rather small, less than 0.2 in larger diameter, distributed from midlevel of or posterior to ventral sucker (or from bifurcal level or slightly behind it) to posterior end of body. Excretory vesicle I-shaped, thick-walled, extending forward into anterior half of posttesticular region but not reaching the posterior testis; excretory pore almost dorsal.

2) Material 2 has been described by YAMAGUTI (1934). Material 3, poorly prepared, agreeing well in morphology with the foregoing description.

Discussion. OZAKI (1926) briefly described this species found in the intestine of *O. uncirostris* from Japan in a preliminary note. He did not figure it. The holotype (No. P. 231) was deposited by him in the collection of the Zoological Institute, Science Faculty, Imperial University of Tokyo, but very probably it has already been lost. Material 1 was identified as *A. hasu* by himself, but it is quite uncertain whether or not it is part of the original type series. Later, YAMAGUTI (1934) published a little more detailed description of this species on the basis of his own specimens (material 2), but he did not illustrate them either. The present study has confirmed the outline of the descriptions by the authors. However, it has shown that the excretory vesicle is tubular and sometimes longer than was described by them, occasionally extending

more anteriorly beyond the midlevel of the posttesticular region.

Dr. YAMAGUTI's collection includes the following three other sets of unpublished specimens which also are considered to be *A. hasu*. 1) Two poorly-prepared immature whole-mounts of *A. hasu* (MPM Coll. No. 22576) found in *O. uncistrostris* from Lake Biwa and "Moroko" from Komatsu (=Lake Biwa) in December 1926. These measured 2.10–2.20 long and had deeply notched testes. A long excretory vesicle reaching the posterior testis in one but not in the other. 2) One shrunk gravid whole-mount of *Allocreadium* (No. 22569) found in the intestine of "Moroko" from Lake Biwa on July 29, 1927. 3) Two immature whole-mounts of *A. hasu* (No. 22286) found in the intestine of *Zacco temmincki* (Cyprinidae) from the Asago River, Hyôgo Prefecture, on March 23, 1932. These were 2.00–2.20 long and had large and deeply lobed testes, relatively small vitelline glands and the excretory vesicle not reaching the posterior testis. One of them possessed a small cirrus pouch lying anterolateral to the ventral sucker, but the other, a much larger one extending posteriorly near to the posterior border of the ventral sucker.

One fully gravid specimen (NSMT-P1 3093) of the genus *Allocreadium* was obtained from the intestine of *Zacco platypus* from the Gô River near Yoshida, Hiroshima Prefecture, on October 30, 1976. In morphology, this specimen closely resembles Dr. OZAKI's specimens of *A. hasu* (material 1), and so it has been tentatively identified as *A. hasu*.

A. hasu inhabits the intestine of *O. uncistrostris* and "Moroko" in Lake Biwa. Its life cycle is unknown. WANG (1981) proposed a new species, *A. (Allocreadium) opsariichthydis*, for a trematode found in *O. uncistrostris bidens* from Shaowu, Fujian, China. This species is similar in morphology as well as in host species to *A. hasu*, though slightly different in the esophagus bifurcating in front of the ventral sucker, the elliptical ovary and the anterior extent of the vitellaria.

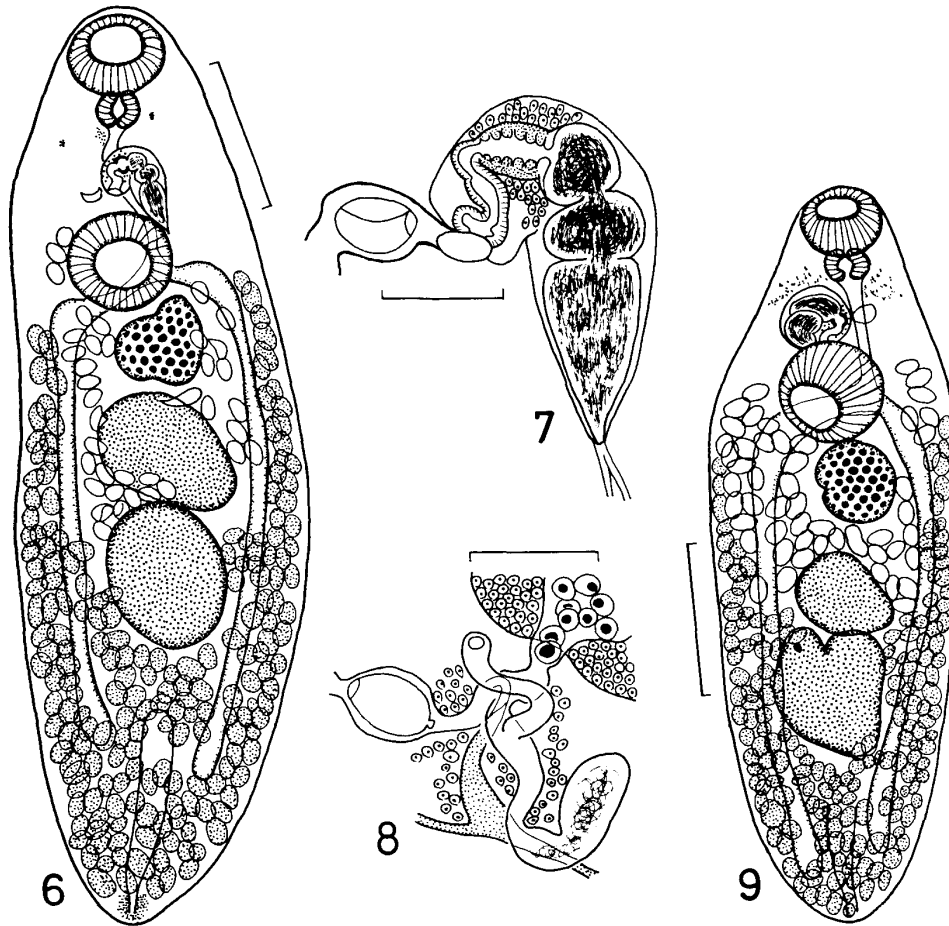
Allocreadium isoporum (LOOSS, 1894) LOOSS, 1900

(Figs. 6–8)

Syn.: *Distomum isoporum* LOOSS, 1894; *Creadium isoporum* (LOOSS, 1894) LOOSS, 1899; *Allocreadium laymani* BYKHOVSKAYA-PAVLOVSKAYA, 1962.

Material examined. Seventeen gravid and 5 immature whole-mounts of *A. isoporum* (NSMT-P1 1838–1844) of SHIMAZU (1981) from the intestine of *Tribolodon ezoe* (Cyprinidae) from the Kushiro River near Lake Tôro, near Kushiro, Hokkaido, on May 10, 1977.

Redescription. Seventeen adults measured (Figs. 6–8). Body elongate, 2.34–3.10 by 0.80–1.20; forebody 25–36% of total body length. Large gland cells present in forebody, with ducts opening on anterior tip of body. Eyespot pigments dispersed or absent. Oral sucker 0.25–0.32 by 0.26–0.32. Prepharynx very short. Pharynx barrel-shaped, 0.12–0.14 in diameter. Esophagus long, 0.43–0.55 long, bifurcating just posterior or posterodorsal to ventral sucker; intestinal ceca ending in anterior



Figs. 6–8. *Allocreadium isoporum* (Looss, 1894) Looss, 1900. Specimens from *Tribolodon ezoe* from the Kushiro River near Lake Tôro, near Kushiro, Hokkaido. — 6. Entire worm, ventral view. 7. Terminal genitalia, ventral view. 8. Ovarian complex, dorsal view. Fig. 9. *Allocreadium* sp. specimen from *Chaenogobius annularis* (the middle-reaches type) from the Shubunbetsu River, Mashike, Hokkaido, entire worm, ventral view. (Scale bars: 0.5 mm in Figs. 6 & 9; 0.1 mm in Fig. 7; 0.2 mm in Fig. 8.)

half of posttesticular region. Ventral sucker distinctly larger than oral sucker, located around anterior one-third of body, 0.31–0.39 by 0.32–0.46; sucker width ratio 1: 1.08–1.51.

Testes round or elliptical, rather large, tandem in middle one-third of hindbody, 0.24–0.47 by 0.31–0.58. Cirrus pouch claviform, anterolateral to ventral sucker, 0.24–0.35 by 0.08–0.13. Seminal vesicle usually tripartite with a stronger anterior constriction, or rarely tubular and sigmoid, occupying posterior two-thirds of cirrus pouch. Pars prostatica oval, small. Cirrus short. Genital atrium inconspicuous. Genital pore at about midlevel of esophagus, or in front of ventral sucker. Ovary globular, reniform or weakly trilobate, median or submedian, just posterior to ventral sucker, 0.18–0.31 by 0.24–0.35. Seminal receptacle retort-shaped, small, posterolateral

to ovary, 0.12–0.16 by 0.06–0.08. Ootype-complex postovarian. LAURER's canal submedian, between ovary and anterior testis. Uterus folding usually pretesticular, occasionally entering intertesticular field; metraterm poorly formed, as long as cirrus pouch. Eggs rather many, not embryonated (or possibly in early stages of development), 60–80 by 50–60 μm in balsam. Vitelline follicles comparatively small, distributed from bifurcal level to posterior end of body. Excretory vesicle extending into anterior half of posttesticular region but not reaching posterior testis; excretory pore posteroterminal.

Discussion. This Hokkaido form of *A. isoporum* is a little different from those previously reported from Europe (LOOSS, 1894; ŚLUSARSKI, 1958; ERGENS, 1964; MORAVEC, 1984) in the ventral sucker being distinctly larger than the oral, the vitellaria reaching more anteriorly to the bifurcal level, the cirrus pouch being smaller and rather poorly developed, and smaller eggs. The latter includes the specimens that ERGENS (1964) identified with *A. i. dubium* KOVAL', 1957, from *Gobio gobio* and *Leuciscus cephalus* and with *A. i. macrorchis* KOVAL' et KULAKOVSKAYA, 1957, from *Barbus barbus*, *G. gobio*, *L. cephalus* and *L. leuciscus* (MORAVEC, 1984). ŚLUSARSKI's (1958) worms from *Salmo trutta* of Poland have the ventral sucker (0.31–0.33 by 0.31–0.308) being a little larger than the oral (0.305–0.308 by 0.245–0.246) and the excretory vesicle very slightly overlapping anteriorly the posterior testis. The position of the anterior limit of the vitellaria has often been emphasized in the taxonomy of *Allocreadium*. It seems to be more appropriate to adopt the relative position of the anterior limit of the vitellaria and the bifurcal level than to use the relative position of the limit and the ventral sucker. The latter have usually been taken into consideration formerly. Since the vitellaria and the digestive tract are embedded close to each other in the parenchyma, the relative position between them is hardly changeable during preparation. On the other hand, the plump ventral sucker is liable to be displaced during fixation especially under pressure. In the above-mentioned European forms, the vitellaria are described as extending forward to the ovarian level or slightly anteriorly to it but not farther to the bifurcal level. However, my examination has shown that the vitellaria almost reach the bifurcal level in two gravid worms of *A. isoporum* (No. D-40 in the collection of the Institute of Parasitology, Prague) from *Noemacheilus barbatulus* and *L. cephalus* from Czechoslovakia. LYAĬMAN (1933) obtained a trematode, which he referred to *A. isoporum*, from *L. idus* and *L. l. baicalensis* from Lake Baikal, Siberia. BYKHOVSKAYA-PAVLOVSKAYA (1962) raised it to an independent species, *A. laymani*, but KOVAL' (1966) synonymized this species with *A. isoporum*. The present Hokkaido form resembles the LYAĬMAN's (KOVAL', 1966) in the egg size but differs from it in the more anterior extent of the vitellaria and the smaller cirrus pouch. The presence of the above-mentioned differences between the present specimens and the European forms of *A. isoporum*, particularly in the size ratio of the two suckers, does not necessarily deny the possibility that the present specimens represent a distinct species. This problem remains to be solved until many other specimens are studied.

A single gravid specimen (NSMT-P1 2935) was found in the intestine of *Chaenogobius annularis* (the middle-reaches type) from the Shubunbetsu River, Mashike, Hokkaido, on July 30, 1984. Its morphology was very closely similar to that of the above-described specimens in every essential characteristic except a larger cirrus pouch being globular and containing a sinuous seminal vesicle (Fig. 9). Its measurements were: body 2.44 by 0.78; forebody 28% of total body length; oral sucker 0.21 by 0.26; pharynx 0.11 by 0.15; esophagus 0.35 long; ventral sucker 0.31 by 0.32; sucker width ratio 1: 1.23; testes 0.26–0.39 by 0.31–0.35; ovary 0.26 in diameter; seminal receptacle very small; and eggs 74–80 by 50–54 μm in balsam. The anterior extent of the excretory vesicle could not be worked out. This worm remains undetermined until additional specimens are obtained.

Allocreadium isoporum is a well-known intestinal parasite of cyprinids and some other fishes in the Palaearctic subregion. For its life cycle, see YAMAGUTI (1975).

Allocreadium japonicum OZAKI, 1926

(Figs. 10–11)

Material examined. 1) Eight whole-mounted (1 immature and 7 gravid) and 6 serially-sectioned gravid specimens of *Allocreadium* (MPM Coll. No. 30007) in Dr. OZAKI's collection from "Haya" (= ?*Tribolodon hakonensis*) (Cyprinidae) from the Tama River, Tokyo (other data not given).

2) Three gravid whole-mounts (unidentified, MPM Coll. No. 30008) in the same collection from "Maruta" (= ?*T. taczanowskii*) from [Shinkawa] (other data not given).

3) YAMAGUTI's (1934) whole-mounts of *A. japonicum* (2 immature and 3 gravid, MPM Coll. No. 22285, from the intestine of *Zacco platypus*; and 1 gravid, No. 22577, from the intestine of *Z. temmincki*) from Lake Biwa, Shiga Prefecture, on July 7 and 10, 1927.

Description. 1) Based on material 1; 6 better whole-mounts measured (Figs. 10–11). Body elongate, 4.00–5.40 by 0.86–1.40; forebody 20–26% of total body length. Gland cells and fine eyespot pigments present in forebody. Oral sucker 0.31–0.39 by 0.33–0.41. Prepharynx very short. Pharynx 0.15–0.22 by 0.15–0.23. Esophagus 0.47–0.63 long, bifurcating from just in front of to midlevel of ventral sucker; intestinal ceca terminating at near posterior end of body. Ventral sucker situated at from anterior one-fifth to one-fourth of body, 0.39–0.57 by 0.39–0.55; sucker width ratio 1: 1.26–1.40.

Testes usually weakly or rarely deeply indented, in tandem, in middle one-third of hindbody, 0.51–0.86 by 0.35–0.79. Cirrus pouch club-shaped, never extending posterior to ventral sucker, 0.27–0.63 by 0.17–0.30. Seminal vesicle S-shaped, filling cirrus pouch. Pars prostatica oval, small. Cirrus short. Genital atrium not seen. Genital pore between pharynx and ventral sucker. Ovary weakly trilobate, triangular or elliptical, median, 0.39–0.59 by 0.23–0.47. Ootype-complex posterodorsal to

ovary. LAURER's canal present. Seminal receptacle large, between ovary and anterior testis, 0.19–0.39 by 0.19–0.31. Uterus coiling usually between anterior testis and ventral sucker; metraterm poorly formed, shorter than cirrus pouch. Eggs numerous, non-embryonated, 80–84 by 44–50 μm in balsam. Vitelline glands varying in shape and size, usually elliptical, rather large, distributed from a little anterior to posterior border of ventral sucker (or from bifurcal level or slightly behind it) to posterior end of body. Excretory vesicle thick-walled, ending anteriorly in anterior one-third of posttesticular region; excretory pore posterodorsal.

The remaining whole-mount, 1.90 long, contained 15 eggs measuring 66–70 by 40–50 μm .

2) The morphology of material 2 was similar to the foregoing description: body 3.60–4.50 by 0.80–1.30; forebody 1.00–1.20 long; oral sucker 0.33–0.38 by 0.35–0.40; pharynx 0.16–0.20 by 0.19–0.22; esophagus 0.40–0.63 long; ventral sucker 0.39–0.47 by 0.43–0.55; sucker width ratio 1: 1.20–1.42; testes 0.47–0.91 by 0.35–0.79; cirrus pouch 0.28–0.55 by 0.17–0.31; ovary 0.35–0.39 by 0.27–0.43; seminal receptacle 0.16–0.27 in diameter; and eggs 80–84 by 48–54 μm in balsam.

3) The measurements of material 3 appear in YAMAGUTI (1934). The testes were large with rather smooth outline, and the eggs in balsam were 70–78 by 46–52 μm . In one of the specimens from *Z. platypus*, the vitelline follicles were small, and the excretory vesicle ended anteriorly midway to the posterior testis. In the others, the vitellaria were larger, but the anterior extent of the excretory vesicle could not be worked out owing to the vitellaria overlying on it.

Discussion. OZAKI (1926) briefly described this species found in the intestine of *Z. platypus* from Japan in a preliminary note without figuring it. The holotype (No. P. 226) was deposited by him in the collection of the Zoological Institute, Science Faculty, Imperial University of Tokyo, but it is very likely that it has already been lost. Later, YAMAGUTI (1934) merely gave the measurements of his own specimens (material 3).

According to PETERS (1957), 1) Professor OZAKI examined specimens of *A. japonicum* at his disposal at that time for him and found no eyespot pigment except in one doubtful specimen, which suggests that the material may include more than one genus; 2) the generic position of this species therefore must await a re-examination of the type specimen; and 3) if it lacks eyespot pigment, this feature as well as the trilobed ovary would indicate that the species may belong to one of the opecoelid genera. I consider, however, that although the original description of the species by OZAKI (1926) says nothing of the eyespot, the combination of the following characteristics is sufficient to allocate it to *Allocreadium*; the unarmed body, the median genital pore opening between the pharynx and the ventral sucker, the presence of the cirrus pouch, the two tandem testes, the pretesticular ovary, the postovarian seminal receptacle, the uterus coiling between the anterior testis and the ventral sucker, the distributional pattern of the vitellaria and the tubular excretory vesicle. There is no information as to whether or not the specimens that Professor OZAKI examined still

exist. At any rate, all the present specimens possess eyespot pigments in the forebody.

When OZAKI (1926) created *A. japonicum* and *A. hasu* as new species in the same preliminary paper, he did not clearly indicate the features distinguishing these two species from each other. It seems that he separated the former from the latter by an oblong body, a larger oral sucker, smaller and more weakly notched testes, larger vitellaria in irregular shape and a longer excretory vesicle. YAMAGUTI (1934) stated that these two very closely related species differ from each other in the size of the body, in the characters of the testes and in the extent of the excretory vesicle. The specimens of material 1-2 much more closely resemble *A. japonicum* than *A. hasu* as described by OZAKI (1926), and so they are regarded as *A. japonicum*. However, differences in morphology, host fish and locality seen between the two species appear to be slight and sometimes indistinct, which is evident from the above. Further, WANG (1984) recorded *A. japonicum* from *Opsariichthys bidens* and *Z. platypus* from Jian'ou, Fujian, China. Future study would demonstrate that they are conspecific. I follow OZAKI (1926) for the time being.

Dr. YAMAGUTI's collection contains three other (two immature and one just matured) unpublished specimens labeled *Allocreadium* (MPM Coll. No. 22285) from the intestine of *Z. platypus* from Lake Biwa on July 10, 1927. The testes have a smooth or slightly indented outline, and the excretory vesicle reaches the posterior testis. Possibly they are *A. japonicum*.

A single immature specimen of *Allocreadium* (NSMT-P1 2936) was obtained from the intestine of *Z. temminckii* from the Gô River near Hibayama, Hiroshima Prefecture, on October 31, 1976. The testes were small but deeply lobed, and the excretory vesicle overlapped anteriorly the posterior testis. This worm remains unidentified until mature specimens are available.

Allocreadium tosai sp. n.

(Figs. 12-14)

Syn.: *Allocreadium transversale* of SHIMAZU (1981).

Material examined. 1) Thirty-two gravid whole-mounts (NSMT-P1 3051) found in the intestine of *Tribolodon hakonensis* from Lake Tôro belonging to the Kushiro River system, near Kushiro, Hokkaido, on July 22, 1984.

2) Three immature and 20 gravid whole-mounts (NSMT-P1 3052-3053) found in the intestine of *T. ezoe* from the same locality on June 28, 1984.

3) Four gravid whole-mounts of *A. transversale* (NSMT-P1 1843-1844) of SHIMAZU (1981) from the intestine of the same species of fish from the Kushiro River near Lake Tôro on May 10, 1977.

4) Two gravid whole-mount (NSMT-P1 3054) collected by Nagasawa from the intestine of *Moroco percunurus sachalinensis* (Cyprinidae) from Lake Shirarutoro near Lake Tôro on September 19, 1981.

Description. 1) Based on material 1 (Figs. 12-14). Body elongate-oval, 1.80-

2.90 by 0.60–0.88; forebody 26–32% of total body length. Eyespot pigments dispersed. Oral sucker 0.17–0.24 by 0.21–0.27. Prepharynx practically absent. Pharynx globular, 0.09–0.13 by 0.08–0.12. Esophagus undulating or straight, long, 0.19–0.39 long, bifurcating just anterior or anterodorsal to ventral sucker; intestinal ceca terminating at about middle of posttesticular region. Ventral sucker larger than oral sucker, at about anterior one-third of body, 0.23–0.35 by 0.27–0.34; sucker width ratio 1: 1.14–1.29.

Testes oval or elliptical, small, oblique, at about posterior one-third of body, 0.15–0.27 by 0.15–0.21. Cirrus pouch oboval, small, curved or not, anterior or anterolateral to ventral sucker, 0.12–0.19 by 0.08–0.12. Seminal vesicle tubular, sinuous, occupying proximal half of cirrus pouch. Pars prostatica claviform. Cirrus short. Genital atrium shallow. Genital pore prebifurcal, usually just in front of ventral sucker. Ovary elliptical, median or submedian, slightly preequatorial, 0.17–0.25 by 0.13–0.19. Ootype-complex posterolateral to ovary. LAURER's canal short. Seminal receptacle retort-shaped, submedian, postovarian, 0.13–0.19 by 0.05–0.06. Uterus always extending laterally to anterior testis to posterior testis; metraterm poorly developed. Eggs fairly many, not embryonated, 92–102 by 60–70 μm in balsam. Vitelline follicles large, distributed from midlevel of esophagus (or halfway between two suckers) to near posterior end of body. Excretory vesicle thick-walled, extending to midlevel of posterior testis; excretory pore posteroterminal.

2) The specimens of material 2 were small as compared with the above description. They contained a few eggs in the uterus, but the egg size was almost equal to that of the latter. Measurements of 20 adults were: body 1.00–1.32 by 0.42–0.54; oral sucker 0.15–0.21 by 0.17–0.25; pharynx 0.06–0.08 by 0.07–0.09; esophagus 0.09–0.15 long; ventral sucker 0.20–0.29 by 0.22–0.29; sucker width ratio 1: 1.20–1.36; testes 0.08–0.14 by 0.07–0.14; ovary 0.09–0.19 by 0.09–0.17; and eggs 84–100 by 60–70 μm in balsam. The specimens of material 3 also proved to have the excretory vesicle extending to the midlevel of the posterior testis. For their measurements, see SHIMAZU (1981). Material 4 agrees well in morphology with material 1.

Hosts. *Tribolodon hakonensis* (type host), *T. ezoe* and *Moroco percnurus sachalinensis* (Cyprinidae).

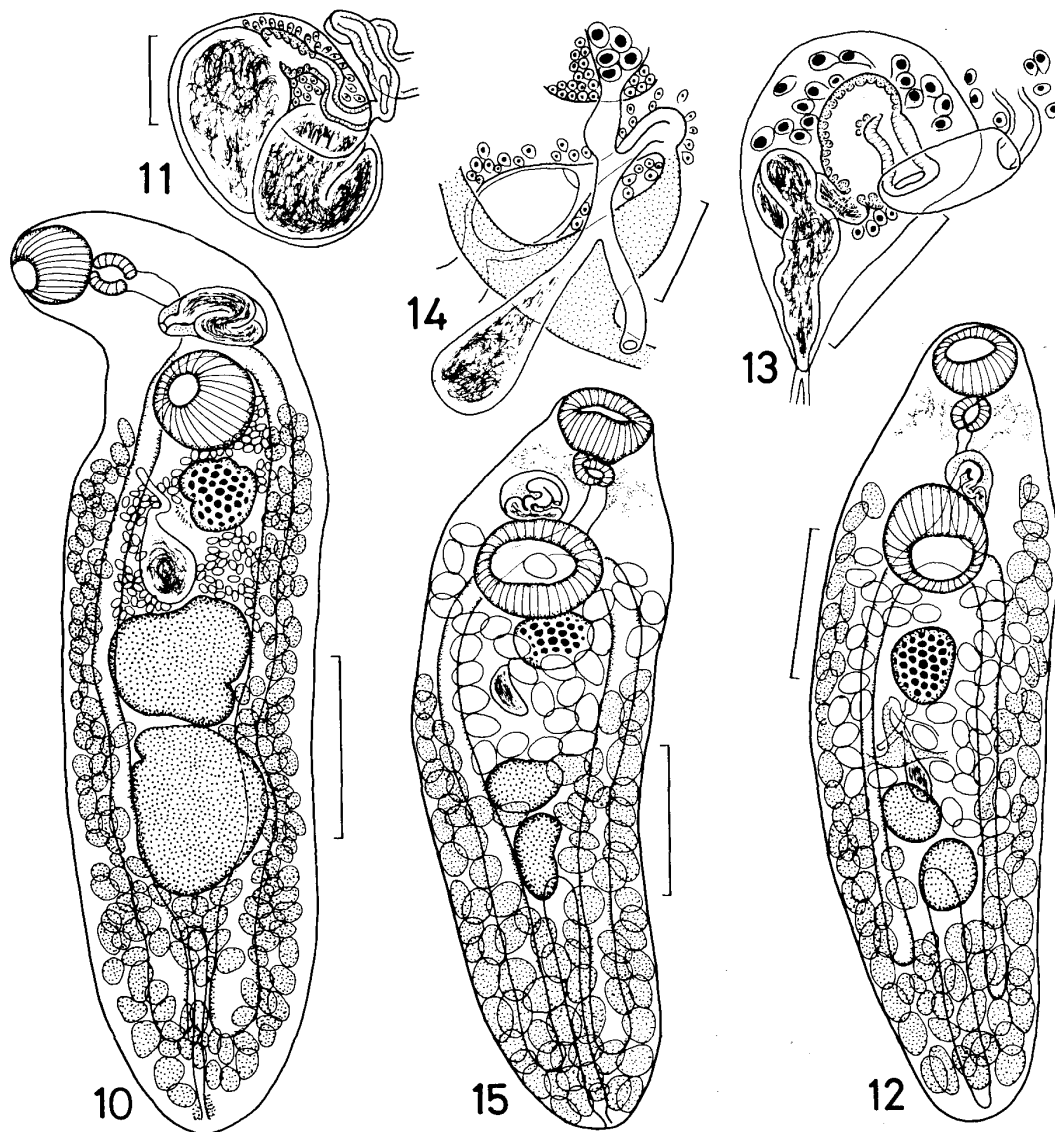
Site of infection. Intestine.

Localities. Lake Tôro (type locality), Lake Shirarutoro and the Kushiro River, near Kushiro, Hokkaido.

Specimens. NSMT-P1 3051 (holotype); 1843–1844 and 3051–3054 (paratypes).

Discussion. In a previous paper (SHIMAZU, 1981), I made a mistake in identifying material 3 with *A. transversale* (RUDOLPHI, 1802) ODHNER, 1901, as discussed below. I also described the excretory vesicle in them as saccular and extending forward at most halfway to the posterior testis, but the present re-examination has proved that the tubular excretory vesicle reaches the midlevel of the posterior testis in them as in the other new specimens.

Allocreadium tosai sp. n. seems to be most closely similar to *A. baueri* SPASSKIĭ



Figs. 10–11. *Allocreadium japonicum* OZAKI, 1926. OZAKI's specimens from "Haya" from the Tama River, Tokyo. — 10. Entire worm, ventral view. 11. Terminal genitalia, ventral view.

Figs. 12–14. *A. tosai* sp. n. Specimens from *Tribolodon hakonensis* (type host) from Lake Tôro (type locality) near Kushiro, Hokkaido. — 12. Holotype, entire worm, ventral view. 13. Terminal genitalia of one of the paratypes, ventral view. 14. Ovarian complex of the holotype, dorsal view.

Fig. 15. *Allocreadium* sp. specimen from *Moroco percnurus sachalinensis* from Saruruto-numa near Lake Tôro, entire worm, ventral view.

(Scale bars: 1 mm in Fig. 10; 0.1 mm in Figs. 11, 13 & 14; 0.5 mm in Figs. 12 & 15.)

et ROÏTMAN, 1960 (SPASSKIÏ & ROÏTMAN, 1960; KOVAL', 1972), but differs from it in a larger size of the body, a smaller sucker width ratio and larger eggs. According to MORAVEC (1984), *A. papilligerum* would be a synonym of *A. baueri*. In such a case,

its longer excretory vesicle also separates this new species from *A. baueri*. Examination of two gravid worms of *A. papilligerum* (No. D-39 in the collection of the Institute of Parasitology, Prague) has shown that the excretory vesicle ends about midway to the posterior testis in them.

The new species is distinct from *A. transversale* as described from Europe (ODHNER, (1901; SZIDAT, 1938; ERGENS, 1964; ŽITŇAN, 1966; KOVAL', 1972; ROBOTHAM & THOMAS, 1982) in a much smaller sucker width ratio (less than 1: 1.3 instead of more than 1: 1.5), the cirrus pouch and genital pore being prebifurcal instead of post-bifurcal, the vitellaria extending into the forebody instead of to the bifurcal level and a longer tubular excretory vesicle mentioned above. With regard to the shape and size of the excretory vesicle in *A. transversale*, there has been published only SZIDAT's (1938) figure (Fig. 1, p. 471) indicating that the organ is saccular and very small. I examined one gravid specimen (No. D-119 in the collection of the Institute of Parasitology, Prague) labeled *A. transversale* from *Cobitis taenia* from Hungary. This worm possesses a very large ventral sucker being prebifurcal (the sucker width ratio being 1: 1.62), the cirrus pouch and genital pore being prebifurcal, the vitellaria extending into the forebody, small testes lying diagonal, the eggs measuring 82–90 by 56–60 μm and the tubular excretory vesicle reaching at least the posterior testis. It is much more closely similar to *A. baueri cobiti* KOVAL' et IZYUMOVA, 1972, from *C. taenia* from the Ukraine (KOVAL' & IZYUMOVA, 1972) than *A. transversale*.

SEKI (1975) reported two unidentified specimens of *Allocreadium* found in the intestine of *Salvelinus leucomaenis* (Salmonidae) from Panketo Lake, Akan, Hokkaido. Having re-examined the specimens (No. 379), SHIMAZU (1981) considered them to be *A. transversale* or a closely related species. Recently, I found other specimens (7 immature and 6 gravid) among SEKI's (1975) specimens of *Crepidostomum farionis* (MÜLLER, 1784) LÜHE, 1909 (No. 374), obtained from the intestine of *Salmo gairdneri irideus* (Salmonidae) from Lake Shikaribetsu near Kamishihoro, Hokkaido, on June 20, 1974. All of these specimens should be assigned to the present new species.

A single matured worm of *Allocreadium* (NSMT-P1 3055) was found in the intestine of *M. p. sachalinensis* from Saruruto-numa (a marsh) near Lake Tôro on July 4, 1984. It very closely resembled the present new species but for larger eggs (106–130 by 70–80 μm in balsam) and more shortly distributed vitellaria reaching forward barely the ovarian level (Fig. 15). Many more specimens should be examined before this fluke is definitely identified.

The present new species is named in honor of Mr. Yoshinori TOSA, who has generously been helping some biologists in their field-work.

Allocreadium sp. of KATAOKA and MOMMA (1934), inc. sed.

KATAOKA and MOMMA (1934) reported three specimens of this trematode from the intestine of *Plecoglossus altivelis* (Plecoglossidae) from Lake Biwa. According to them, the morphology of a single gravid whole-mount is as follows.

Body ellipsoidal, somewhat elongated, smooth, 2.23 by 0.73 in middle part. Oral sucker protruding anteriorly, 0.16 in diameter. Prepharynx absent. Pharynx globular, 0.12 in diameter. Esophagus short, 0.093 long, bifurcating in front of ventral sucker into intestinal ceca. Ventral sucker larger than oral sucker, 0.296 by 0.31, situated on median line a little anterior to one-sixth of body length. Sexual organs occupying the whole part behind ventral sucker. Cirrus pouch, genital pore, uterus and excretory vesicle all indistinct. Testes tandem, close to each other on median line; anterior testis almost round, 0.41 by 0.44, posterior one irregularly ellipsoidal, 0.59 by 0.38. Ovary kidney-shaped, 0.067 by 0.14, pretesticular. Seminal receptacle elongated gourd-shaped, dorsal to ovary. Vitelline follicles comparatively gross, not compact, distributed posterior to ventral sucker along both lateral margins, uniting behind posterior testis. Eggs oval, operculated, 0.073 by 0.049.

Assigning the trematode to *Allocreadium*, they stated that it closely resembled *A. oncorhynchi* EGUCHI, 1931, at present *Dimerosaccus oncorhynchi* (EGUCHI, 1931) SHIMAZU, 1980 (Opecoelidae) (SHIMAZU, 1980). Their description without figure is too inadequate to identify it even to generic level at present. The presence of the seminal receptacle indicates that it is not *D. oncorhynchi*. Their specimens need re-examination, but they have not yet been located. It will be necessary to collect new specimens from *P. altivelis* from Lake Biwa.

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